



# Department 1411 Review

May 16, 2006

Steve Thomas

Computational Science for Microsystems:

Demonstrate Value to MESA of Modeling, Simulation, Optimization

MESA Program 0.50 FTE

ASC/Algs/Opt 0.25 FTE

Algorithm Research: Uncertainty Bounds on Engineering Models without assuming Bayesian prior distributions (PRIDE LDRD)

0.25 FTE

SAND2006-3621P



# Demonstrate Value of Modeling, Simulation and Optimization to MESA

**Programmatic Issue:** How does one demonstrate value of MSO to microsystems research and exploratory design departments in MESA? (Can be a very different activity than capability development!)

**Activities:** Introduce new designs, new design approaches based on optimization to MESA's RF Ohmic Switch/RF Circuit Design Team

**Thesis:** Can gain confidence/cooperation of microsystems engineers by demonstrating that MSO for understanding in design process leads to **better performing designs**.

**Results:** Created EV2 Switch Design approach, leading to:  
Demonstrated potential of MSO to solve switch performance issues  
Designer involvement in MSO-based re-design  
New approach to iterative MSO as part of design  
Demonstration of need for new simulation technologies  
New designs for fabrication this Summer

Switched RF Circuits: Demonstration that High Performance ASC simulation is necessary to predict RF antenna circuit performance

**Impact:** Demonstration of the opportunity for 1400 and MSO leadership in microsystems engineering innovation



# MESA's RF Ohmic Switch Design/Understanding Team\*

Chris Dyck – 1742 – fab process and switch design

Rick Kellog – 2615 – switch design

Jordan Massad – 1526 – Andante analysis

Clay Fulcher – 1526 – Salinas analysis and optimization

Anton Sumali – 1526 – laser Doppler micro-diagnostics

Carl Diegert – 1424 – micro-strobe dynamic diagnostics

Bernd Strassner 5345 – RF switched circuit design

Joseph Kotulski – 1652 – distributed RF circuit simulation

Steve Thomas -1411 – design innovation/optimization

\*with much valuable assistance from others

# The EV2 Design Approach

Opportunity for switch performance improvement

## **Cross Section Diagram of electrostatic retractor design**

Deleted because of business sensitivity

Contact [swthoma@sandia.gov](mailto:swthoma@sandia.gov) for more information

## **3D Parameterized Drawing of EV2 design class**

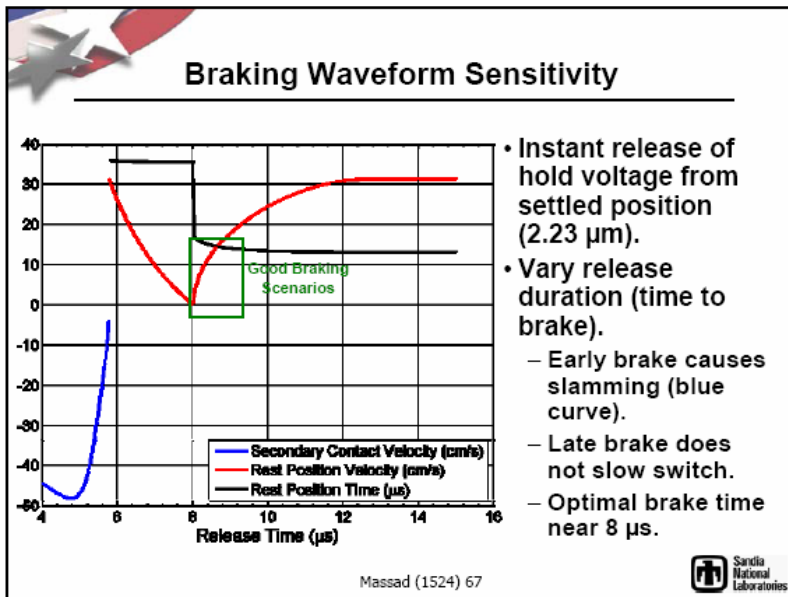
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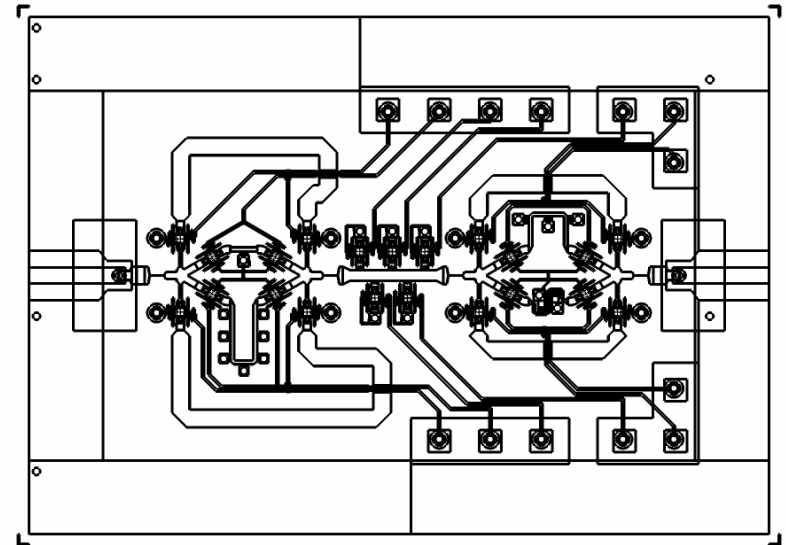
New: Electrostatic retraction instead of springs

Parametric design for optimization

# We are about 2/3 the way to full understanding and optimizing



Validation by Fab/Test this Summer




Data for validation have been gathered. Runs await funding.



## Our Team has achieved measurable recognition for MSO in 1740

- Meetings with switch design/fab staff from 1742 are now weekly.
- Simulation-based designs including EV2 are now receiving second and third looks to assure they can be fabricated
- We have been asked to optimize, compare the existing, fabricated E design with respect to fab-sensitivity
- As a design TEAM we are exploring the potential for a wide range of other novel designs incorporating electrostatic retractors



# Future Research: Funded Late Start FY06 LDRD's

**LDRD: 06-1601** New Processes for Innovative Microsystems

Engineering with Predictive Simulation – Steve Thomas

**Hypothesis:** Engineering processes employing predictive simulation for iterative understanding will lead to more microsystems innovation.

**LDRD: 06- 1743** Model-based Statistical Estimation of Sandia's

RF Ohmic Switch dynamic operation from stroboscopic, x-ray imaging – Carl Diegert

**Hypothesis:** Strobed x-ray imaging can give us info we need to better unravel MEMS dynamics

**LDRD: 06-1823** Enabling technologies for Shape Optimization of Armor  
and Other Defense Assets New Processes– Steve Owen

**Hypothesis:** Parametric geometric modeling/meshing will enable even better capabilities to optimize design shape – at MEMS scale and larger!



# Algorithm Research: Uncertainty Bounds on Engineering Models without Bayesian Assumptions

**Programmatic Issue:** How can one usefully characterize (for Validation, Prediction, Optimization) the uncertainty in engineering modeling and simulation WITHOUT Bayesian assumptions that seem implausible to engineers?

**Activities:** Create and explore a math theme in estimation theory applied to predictive science.

**Thesis:** One can remove the Gaussian (or any distribution) assumption from the Standard DACE model and still get useful prediction error bounds

**Results:** 1) Surprising (to me) result that an optimization algorithm can be formulated with provable global convergence.  
2) Computable deterministic bounds on calibrated simulation output can be proved, without any a priori distribution assumptions.

**Impact:** With new algs and codes, potential for a large increase in the engineering confidence of the predictive capability of MSO.